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# Mission Highlights

# STS-70

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## TDRS deploy and use of new MCC highlight mission

*Discovery's* launch in the morning hours of July 13, 1995, brought telecommunications and Shuttle hardware to new levels with deployment of another Tracking and Data Relay Satellite (TDRS), the first flight of a new Block 1 engine and the first use of a new state-of-the-art Mission Control Center (MCC).

The crew successfully deployed TDRS with its attached Inertial Upper Stage (IUS) from *Discovery's* cargo bay. The IUS, consisting of two solid rocket motors, helped the satellite reach its geosynchronous orbit and then separated from the satellite to allow the satellite's appendages to deploy.

TDRS not only improves communications for Shuttle missions but enhances data acquisition from several other space customers including the Hubble Space Telescope, the Compton Gamma Ray Observatory, the Upper Atmosphere Research Satellite, the Extreme Ultraviolet Explorer, TOPEX-POSEIDON and others.

The Block 1 engine was designed to increase the crew's safety during launch and improve performance and reliability. The new high pressure liquid oxidizer turbopump located inside the Block 1 engine has 300 fewer welds than the existing pump. The new pump also lasts longer before detailed inspections must be done. The old pump was removed after every flight for inspection, the new one only after 10 flights.

**The Tracking and Data Relay Satellite is deployed from *Discovery's* cargo bay.**

## Space Shuttle *Discovery*

July 13-22, 1995

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| **Commander:** | Terence "Tom" Henricks |
| **Pilot:** | Kevin R. Kregel |
| **Mission Specialists:** | Donald A. Thomas<br>Nancy J. Currie<br>Mary E. Weber |

**Commander Tom Henricks positions the HERCULES camera in the Shuttle window.**

The Space Shuttle *Discovery* was nearly flawless throughout the mission, providing a stable platform for a number of experiments. The flight's biggest obstacle arose before the Shuttle left the ground when industrious Florida woodpeckers chiseled nearly 200 holes in the ship's external fuel tank insulation causing the postponement of launch until repairs could be completed.

Experiments aboard *Discovery* looked at the effects of microgravity on plants, small invertebrate animals and insects. The Bioreactor Development System (BDS), developed at JSC, grows individual cells into tissue. During the mission, the crew downlinked video images of bioreactor tissue cultures that were described as better than any seen before by investigators working to qualify the machinery for use on orbit. Bioreactors are extensively used on Earth to grow three-dimensional cell cultures that cannot be produced by traditional culture methods. The BDS was used to determine how effective the equipment was for supporting tissue growth with minimal cell damage.

STS-70 was also the first Shuttle flight in which ground support used the new MCC. This marked the beginning of the end for the current MCC. After a gradual phasing-out period, the current facility will remain as a national monument.

The new control center eliminates the NASA-unique equipment and massive hardware orientation of the current MCC, replacing it with a modular, software-oriented design that uses standard, commercially available equipment. It offers an unprecedented flexibility in flight control operations, allowing the facility to be changed from controlling a Space Shuttle to controlling any other spacecraft with almost the speed and simplicity of choosing a different function from a computer menu. The up-to-date technology used in the new MCC will greatly reduce maintenance costs for the facility as well.

## Mission Events

Following an 8:42 a.m. CDT launch, the Tracking and Data Relay Satellite-G, the sixth and last such satellite to be deployed from a Space Shuttle, was ejected from *Discovery's* cargo bay at 2:55 p.m. CDT. After the deployment, flight controllers moved to the new MCC for all on-orbit operations.

On day two, the crew worked with experiments ranging from the HERCULES camera, a camera that can imprint the latitude and longitude of areas photographed on Earth, to WINDEX, a study of the glow created as the Shuttle surfaces interact with atomic oxygen in low Earth orbit. The experiment was used to better characterize the glow, which occurs on all spacecraft in low orbit, and thus better design Earth orbiting, sensitive astronomy satellites with which such a glow could interfere.

Day three was used to conduct and monitor nearly 20 different science experiments on the orbiter's middeck and flight deck, work with the HERCULES camera and check out the Bioreactor Development System (BDS). Other work included an experiment that gauges astronauts' reflexes and hand-eye coordination. Another observation was made with the Windex experiment as well.

On day four, Mission Specialist Mary Ellen Weber reported that colon cancer tissue samples growing in the BDS looked far better than those cultured on the ground. In another study, the Visual Function Tester, crew members reported their eyesight is affected slightly by weightlessness, taking somewhat longer to adjust and focus on near objects.

On day five Mission Specialist Nancy Currie sent down video images of developing Medaka fish eggs as part of the Space Tissue Loss experiment and filled out responses to a human factors research project that looked at ways to optimize astronaut performance on orbit. In addition, the crew continued work on the HERCULES camera, used WINDEX to observe Shuttle thruster firing, checked on the progress of BDS, and answered queries posed by Internet surfers visiting NASA's Shuttle Web.

Day six saw the activation of the Microencapsulation in Space Experiment, a device that attempted to produce a timed-release antibiotic medication in weightlessness. The lack of gravity allows the encapsulation process to be performed with much greater purity than can be achieved on the ground. The automated investigation operated while the crew slept. The crew also downlinked video images of bioreactor tissue cultures. The video showed orange colon cancer cells coalescing into globules, some as large as a pea.

The highlight of day seven was Pilot Kevin Kregel downlinking both live and videotaped images from the HERCULES camera following the successful alignment of the camera's navigation equipment. Other experiments continued as scheduled. After final sessions, the crew stowed the HERCULES camera and WINDEX for the return to Earth. Thomas also reported success with the Shuttle Amateur Radio Experiment (SAREX) amateur radio aboard the Shuttle, counting approximately 50 contacts with ground radio operators a day for several days of the mission. The crew spoke with students at 10 schools scattered around the globe.

Day eight was spent wrapping up the remaining experiments and stowing them for the trip home. Due to low clouds and fog at the Kennedy Space Center, the landing was postponed 24 hours, and *Discovery* returned to Earth at 7:02 a.m. CDT, on July 22, 1995.

## Additional Payload Descriptions

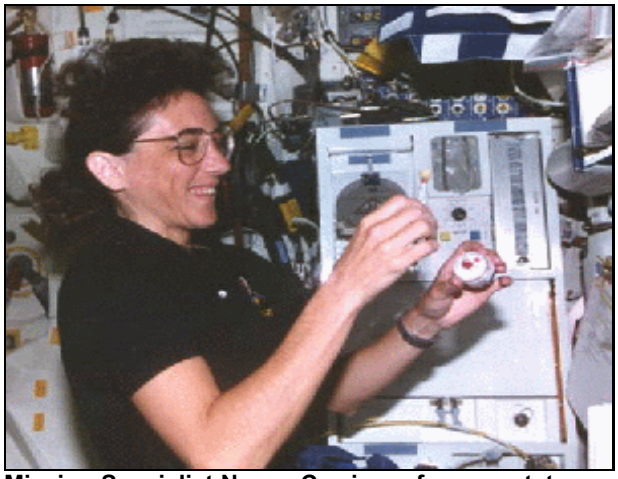
The Biological Research in Canisters (BRIC) experiments were designed to examine the effects of microgravity on a wide range of physiological processes in plants, insects, and small invertebrate animals. Space flight has been shown to affect the hormone systems of humans, animals and insects, as well as increasing muscle degeneration of crew members. The BRIC-4 experiment, flown on STS-70, examined the tobacco hornworm, whose hormone system and muscle formation appear to be sensitive to an altered gravitational field.

Human exploration of space depends on our ability to grow plants in microgravity. For long duration space missions it will not be possible to store the necessary volume or mass of food required for extended space missions. The BRIC-5 experiment tested whether the cell division changes observed in the daylily are the result of the direct effects of microgravity or indirect effects such as water availability.

Just as gravity affects the manner in which crystals grow and materials are processed, Earth's pull also can alter the development of cells and tissues. The Bioreactor Demonstration used space-bioreactor systems to grow individual cells into organized tissue that is morphologically and functionally similar to the original tissue or organ. The experiment protocol used colon cancer cells as a test of the bioreactor performance.

There were five National Institute of Health-R-2 experiments onboard STS-70. The Space Flight Effects on Mammalian Development experiment emphasized features of rat behavior and physiology that were known to contribute to successful pregnancy, labor, delivery and the onset of postnatal care - especially lactation. Development of vestibular (balance) function in all species begins well before birth. The use of pregnant animals exposed to microgravity eliminated the effects of gravity from direct input during the development of this system. Examination of the behavior of offspring after birth provided information about the earliest development of the vestibular system under gravity as compared to microgravity circumstances. The experiment was developed at the Indiana University Department of Psychology at Bloomington, Indiana.

The Neuromuscular Development and Regulation of Myosin Expression experiment determined whether gravity is required prior to birth for the normal development of muscles. Prior to birth, muscle cells migrate to the limbs and form specific muscles. The muscle fibers within the muscle go through a series of changes until they reach their adult state.



**Mission Specialist Nancy Currie performs a status check on the Commercial Protein Crystal Growth experiment.**

This study determined whether exposure to microgravity during embryonic development affects the normal development of muscles and nerves by examining the innervation of muscles by nerves, the development of muscles and the differentiation of muscle fibers into adult types. The experiment was developed by the Department of Orthopedics at the University of California-San Diego and the VA Medical Center in La Jolla, California.

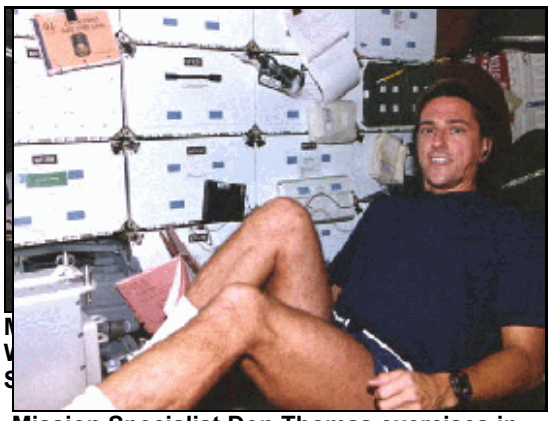
The Effect of Space Flight on the Development of the Circadian Timing System investigated the development of the neurologic system, particularly the retina and its connections in the brain, and the circadian timing system, the internal "clock" which regulates sleep-wake cycles and other daily body functions. The circadian timing system is an important organizer controlling both the physiology and behavior of organisms. For example, conditions such as jet-lag, shift work and some sleep and mental disorders are frequently associated with dysfunction of the circadian timing system. The exposure of developing rat offspring to microgravity may lead to alterations in these systems. The experiment was developed at the Section of Neurobiology, Physiology and Behavior at the University of California, Davis, California.

The Effect of Microgravity on Bone Development experiment investigated the excretion of enzymes by fetal and postnatal rats exposed to microgravity before birth. Under conditions of weightlessness, humans and experimental animals show loss of bone mass. The findings of this study shed light on the importance and role of gravity in developing skeletal bone. The information gained may help in the therapeutic intervention of bone diseases on Earth, such as osteoporosis. The experiment was developed by the Saint Louis University Medical Center, Department of Pharmacological and Physiological Science, St. Louis, Missouri.

The Histological Effects of Microgravity on Rat Body Wall Musculature experiment tested the postural muscles in the hind limbs of rodents which deteriorate dramatically under extended periods of weightlessness. The muscles of the body wall of rodents and other quadrupeds are themselves postural muscles that help elevate the abdomen and flex the spine during locomotion.

Additionally, these muscles are extremely important in a variety of visceral functions that require large increases in abdominal pressure (e.g., coughing, defecation, parturition, etc.). If these muscles deteriorate, as do hind limb postural muscles, this may severely compromise the ability of animals to give normal vaginal birth as a result of being exposed to microgravity.

Greater understanding of the basic physiological processes involved in this research provided insight into a range of medical challenges from diseases involving severe muscle degeneration, to helping accident



**Mission Specialist Don Thomas exercises in flight on the ergometer.**

victims who are immobilized with bedrest for extended periods of time, to developing countermeasures for severe muscle degeneration. The experiment was developed by the Department of Anatomy and Neurobiology, Dalhousie University, Halifax, Nova Scotia, Canada.

The Commercial Protein Crystal Growth (CPCG) experiment aboard STS-70 was sponsored by the Center for Macromolecular Crystallography based at the University of Alabama at Birmingham. This experiment consisted of the Protein Crystallization Facility (PCF). The objective of the PCF experiment, contained in a thermal control enclosure located in *Discovery's* middeck, was to crystallize human alpha interferon protein. Alpha interferon is a protein pharmaceutical that is used against human viral hepatitis B and C. The objective was to discover the next generation alpha interferon pharmaceuticals and formulations. This research, with the aid of pharmaceutical companies, may lead to a whole new generation of drugs which treat diseases such as cancer, rheumatoid arthritis, periodontic disease, influenza, septic shock, emphysema, aging and AIDS.

The Space Tissue Loss-B experiment is a collaborative research project between Walter Reed Army Institute of Research, Washington, DC, and the NASA Life & Microgravity Sciences and Applications Division, Washington, DC. The project investigated the effects of microgravity on embryogenesis. The analysis centered on the evaluation of a very well described and understood biology model, the Medaka fish egg.

The Microencapsulation in Space project was developed at Southern Research Institute and sponsored by the U.S. Army Dental Research Detachment, Walter Reed Army Institute of Research. The purpose of this project was to produce a novel pharmaceutical (microencapsulated antibiotic) in weightless conditions using equipment that has been improved since the first MIS flight in 1992 (STS-53). In the experiment, the drug (ampicillin) was entrapped within a biodegradable polymer, so that as the polymer degraded in the body, the drug was released at a controlled rate. Microencapsulated antibiotics, which are capable of providing precise and predictable sustained drug release rates, control wound infections more effectively than systemically administered antibiotics and do so in vivo after a single application to infected wounds. The result is that all microorganisms in the wound are killed by the antibiotic, and the drug carrier (polymer) dissolves in the body leaving no residue.

HERCULES-B was the third generation of a space-based geolocating system which responded to requirements that exploit multispectral techniques. The geolocation part of the system, built by the Naval Research Laboratory, calculates and tags every frame of video with latitude and longitude with an accuracy of three nautical miles.

The Midcourse Space Experiment was a Department of Defense program sponsored by the Ballistic Missile Defense Office, designed to support the development of surveillance capabilities of ballistic missiles during the midcourse of their flight. The principal instrument of the program is a satellite in a 99 degree inclination, 898 kilometer altitude polar orbit.

The Office of Naval Research sponsored the Military Applications of Ship Tracks (MAST) experiment on STS-70. MAST was developed to examine the effects of ships on the marine environment. This helps in understanding the effects of man-made aerosols on clouds and the resulting impact on the climate system.

Radiation Monitoring Equipment-III (RME-III) was an instrument that measured the exposure to ionizing radiation on the Space Shuttle. The data collected by this equipment is used to assist space planners to more accurately assess risk and safety factors in future long-term space missions, such as the International Space Station.

The objective of WINDEX was to gain an understanding of the chemistry and dynamics near a Low-Earth Orbit (LEO) satellite. This information prevents misinterpretation of the measurements of the Earth, solar system, and stars from LEO platforms. This knowledge also prevents damage to sensitive systems and solar arrays during rendezvous and docking operations.

Since the Gemini space flights, some of NASA's Shuttle astronauts have described a loss in their ability to see clearly at close range when in space. Affected most by this phenomena are those with normal uncorrected vision on Earth. Vision scientists at Human Systems Center's Armstrong Laboratory invented and patented the Vision Function Tester-4 to find out

**Pilot Kevin Kregel and Mission Specialst Nancy Currie work with experiments on the middeck.**

why. Used aboard STS-70, the instrument and the data it gathered help scientists evaluate how quickly the eye adjusts in space and how it is affected over time.

## Crew Biographies

**Commander: Terence "Tom" Henricks.** Henricks, 42, was born in Bryan, Ohio, but considers Woodville, Ohio, to be his hometown. He received a bachelor's degree in civil engineering from the United States Air Force Academy and a master's in public administration from Golden Gate University.

Henricks completed his pilot training at Craig Air Force Base in Selma, Alabama, and F-4 conversion training at Homestead Air Force Base in Miami, Florida. He then flew in F-4 fighter squadrons in England and Iceland. He attended the U.S. Air Force Test Pilot School in 1983 and remained at Edwards Air Force Base, California, as an F-16C test pilot and Chief of the 57th Fighter Weapons Wing Operating Location until he was selected as an astronaut in 1985.

Henricks served as pilot of two space flights. His first mission was STS-44 in November 1991, whose primary objective was to deploy the Defense Support Program satellite with an Inertial Upper Stage rocket booster. His second mission, STS-55 in April 1993, was a cooperative Spacelab mission in with the German Space Agency which included 89 different experiments in materials processing, life sciences, robotics, Earth mapping, technology and astronomy.

With the completion of STS-70, Henricks has logged over 640 hours in space.

**Pilot: Kevin Kregel.** Kregel, 38, was born in New York City, but considers Amityville, New York, to be his hometown. He earned a bachelor's degree in astronautical engineering from the U.S. Air Force Academy and a master's degree in public administration from Troy State University.

Kregel earned his pilot's wings in 1979 at Williams Air Force Base, Arizona. From 1980 to 1983, he was assigned to F-111 aircraft at RAF Lakenheath. While serving as an exhange officer flying A-6E aircraft with the U.S. Navy at NAS Whidbey Island in Seattle, Washington, and aboard the USS Kitty Hawk, Kregel made 66 carrier landings during a cruise of the Western Pacific. His next assignment was another exchange tour at the U.S. Naval Test Pilot School at Patuxent River, Maryland. Upon graduation, he was assigned to Eglin Air Force Base, Florida.

Kregel resigned from active duty in 1990 to take a position as an aerospace engineer and instructor pilot at JSC's Ellington Field offices. His primary responsi-bilities included flying as an instructor pilot in the Shuttle Training Aircraft and conducting the initial flight test of the T-38 avionics upgrade.
Selected as an astronaut in March 1992, Kregel has served on the Astronaut Support Personnel Team at the Kennedy Space Center. He now has more than 235 hours of space flight experience.

**Mission Specialist: Donald Thomas, Ph.D.** Thomas, 40, is a Cleveland, Ohio, native and holds a bachelor's degree in physics from Case Western Reserve University, and master's and doctorate degrees in materials science from Cornell University.

Following his graduation, Thomas joined AT&T Bell Laboratories in Princeton, New Jersey, working as a senior member of the technical staff. He also served as an adjunct professor in the Physics Department of Trenton State College. He holds two patents and has authored several technical papers.

Thomas left AT&T in 1987 to work for Lockheed Engineering and Sciences Company in Houston, where his responsibilities involved reviewing materials used in the Shuttle payloads. In 1988, he joined JSC as a materials engineer, working on analysis of advanced composite materials for use on the International Space Station. He also was principal investigator for the Microgravity Disturbances Experiment on STS-32.

Thomas was selected as an astronaut in January 1990. His first mission, STS-65 in July 1994, was a 15-day Spacelab flight which included 80 experiments focusing on materials and life sciences research in space. With the completion of STS-70, Thomas has logged more than 589 hours in space.

**Mission Specialist: Nancy Currie (Maj. USA).** Currie, 36, was born in Wilmington, Delaware, but considers Troy, Ohio, to be her hometown. She received a bachelor's degree in biological science from Ohio State University and a master's in safety engineering from the University of Southern California.

Following her graduation from Ohio State University, Currie served as a neuropathology research assistant at the OSU College of Medicine. She was commissioned as a lieutenant in the U.S. Army in July 1981 and has served in a variety of leadership positions including helicopter instructor pilot, section leader, platoon leader and Brigade Flight Standardization Officer. As a senior army aviator, Currie has logged over 3,300 flying hours in a variety of rotary-wing and fixed-wing aircraft. She has instructed in all phases of rotary-wing flight, including combat skills and night vision goggle operations.

She was assigned to JSC in September 1987 as a flight simulation engineer on the Shuttle Training Aircraft and was subsequently selected as an astronaut in 1990. Since joining the astronaut corps, she has served as the lead for

**Crew members pose on orbit in front of the Ohio State flag. They are left to right-Don Thomas, Nancy Currie, Tom Henricks, Mary Ellen Weber and Kevin Kregel. All but Kregel are natives of the Buckeye state.**

# STS-70 Quick Look

Launch Date: July13, 1995
Launch Time: 8:42 a.m. CDT
Launch Site: KSC Pad 39B

Orbiter: *Discovery* (OV-103) 21st flight
Orbit/In.: 160 naut miles 28.45 degrees

Mission Duration: 8 days, 22 hours, 21 minutes
Landing Date: July 22, 1995
Landing Time: 7:02 a.m. CDT
Landing Site: Kennedy Space Ctr.

Crew: Tom Henricks, (CDR)
Kevin Kregel, (PLT)
Don Thomas, (MS1)
Nancy Currie, (MS2)
Mary Ellen Weber, (MS3)

Cargo Bay Payloads: TDRS/IUS

Middeck Payloads: BRIC
BDS
CPCG
NIH R-2
In-Cabin Payloads: HERCULES
MIS-B
MAST
RME-III
SAREX
WINDEX
VFT-4

flight crew equipment, the Remote Manipulator System and as a spacecraft communicator.

Her first space flight occurred in June 1993 on STS-57. The primary objective of the mission was to retrieve the European Retrievable Carrier satellite. The mission also featured the first flight of the Spacehab module, carrying 22 microgravity experiments and featuring a space walk by two crew members. After STS-70, Currie had accumulated 474 hours in space.

**Mission Specialist: Mary Ellen Weber (Ph.D.).** Weber, 32, was born in Cleveland, Ohio, but considers Bedford Heights, Ohio, to be her hometown. She holds a bachelor's degree in chemical engineering from Purdue and a doctorate in physical chemistry from the University of California-Berkeley.

During her undergraduate studies at Purdue, Weber held engineering internships at Ohio Edison, Delco Electronics and 3M. After her graduation, she joined Texas Instruments to research new techniques in microelectronics manufacturing. In 1990, she was assigned to SEMATECH, a U.S. semiconductor manufacturing consortium in Austin, Texas, to develop novel high-density plasma reactors for silicon etching. This work led to a further assignment at Applied Materials and Technology in Santa Clara, California, to develop a world-class plasma etcher. She holds one patent and has published eight technical papers. She also is a nationally competitive sky diver with more than 1,900 jumps.

Weber was selected as an astronaut in March 1992. Since then, she has assisted in Shuttle processing and launches for the Astronaut Office and has worked in the Shuttle Avionics Integration Laboratory. Following STS-70 she had logged 235 hours of space flight.


**The STS-70 crew patch depicts the Space Shuttle *Discovery* orbiting Earth in the vast blackness of space. The primary mission of deploying a NASA Tracking and Data Relay Satellite is depicted by three gold stars. They represent the triad composed of spacecraft transmitting data to Earth through the Tracking and Data Relay Satellite System. The stylized red, white, and blue ribbon represents the American goal of linking space exploration to the advancement of all humankind.**